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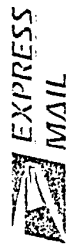
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ATTORNEY DOCKET NO.: 990453 U1 USA

INVENTOR(S): Ralph H. Echols
Perry C. Shy

TITLE: METHODS FOR OPEN HOLE SAND
PACKING WITH EXPANDABLE SCREENS

Spec.-No. of Pages 13

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

Our Docket No. 990453 U1 USA

Ralph H. Echols
Perry C. Shy

For: "METHODS FOR OPEN HOLE SAND PACKING
WITH EXPANDABLE SCREENS"

TRANSMITTAL LETTER

Commissioner for Patents
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Sir:

Attached hereto for filing in the United States Patent and Trademark Office is the patent application identified above, comprising:

1. Specification (with 12 claims)
2. Formal Drawings (3 Sheets)
3. Declaration and Power of Attorney
4. Temporary Filing Receipt (return postcard)

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| Number of independent claims, Minus 3, times \$78.00 | |
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In the event the Examiner wishes to contact attorneys of record concerning the merits of the accompanying application prior to the first Office Action, such contact should be made with the undersigned attorney.

Very truly yours,

HALLIBURTON ENERGY SERVICES, INC.



By: PAUL I. HERMAN
Registration No. 37,349

Date: July 27, 2000

Enclosures

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DECLARATION AND POWER OF ATTORNEY

As a below named inventor, I hereby declare that:

This declaration is of the following type:

- ☒ original
- ☐ design
- ☐ supplemental
- ☐ national stage of PCT

My residence, post office address, and citizenship are as stated below next to my name,
I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

"METHODS FOR OPEN HOLE SAND PACKING WITH EXPANDABLE SCREENS"

the specification of which: (check one)

- ☒ is attached hereto.
- ☐ was filed on , as Application Serial No. , and was amended on -- (if applicable)
- ☐ was described and claimed in PCT International Application No. -- filed on -- and as amended under PCT Article 19 on -- (if any).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose all information known to be material to the patentability of any claim in accordance with Title 37, Code of Federal Regulations, §1.56, and which is material to the examination of this application, namely, information where there is a substantial likelihood that a reasonable examiner would consider it important in deciding whether to allow the application to issue as a patent.

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

PRIOR FOREIGN APPLICATION(S)

| <u>Number Claimed</u> | <u>Country</u> | <u>Day/Month/Year Filed</u> | <u>Priority</u> |
|---------------------------|----------------|-----------------------------|--|
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I hereby claim the benefit under Title 35, United States Code, §119(e) of any United States provisional application(s) listed below:

| <u>Number Claimed</u> | <u>Month/Day/Year Filed</u> |
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This declaration is of the following type: (if applicable)

- ☐ divisional
- ☐ continuation
- ☐ continuation-in-part (CIP)

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

| <u>Application Serial No.</u> | <u>Filing Date</u> | <u>Status Patented/Pending/Abandoned</u> |
|-----------------------------------|------------------------|--|
|-----------------------------------|------------------------|--|

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. WILLIAM E. SHULL, Reg. No. 29,438; PAUL I. HERMAN, Reg. No. 37,349; WILLIAM M. IMWALLE, Reg. No. 35,904; WILLIAM R. PEOPLES, Reg. No. 25,906; ROBERT A. KENT, Reg. No. 28,626 and CRAIG W. RODDY, Reg. No. 36,256 of **HALLIBURTON ENERGY SERVICES, INC.**, P. O. Box 819052, Dallas, Texas 75381-9052 and JOHN F. BOOTH, Reg. No. 25,325, GERALD G. CRUTSINGER, Reg. No. 25,100, DAVID L. JOERS, Reg. No. 31,526, TODD E. ALBANESI, Reg. No. 36,426, MICHAEL T. KONCZAL, Reg. No. 45,475. PETER V. SCHROEDER, Reg. No. 42,132 and JAMES O. DIXON, Reg. No. 18,814 of **CRUTSINGER & BOOTH**, 1601 Elm Street, Suite 1950, Dallas, Texas 75201

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

| | | | |
|---|---|-----------------------------|------------------------------|
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| | Perry C. Shy | <i>Perry C. Shy</i> | 7/27/2000 |
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| | | | |

METHODS FOR OPEN HOLE SAND PACKING WITH EXPANDABLE SCREENS

Inventor: Ralph H. Echols
Perry C. Shy

Attorney Docket: 990453 U1 USA

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Kathy Williams
Type or Print Name of Person Mailing

Kathy Williams
Signature of Person Mailing

July 27, 2000
Date

METHODS FOR OPEN HOLE SAND PACKING WITH EXPANDABLE SCREENS

TECHNICAL FIELD

The present inventions relate to sand-control apparatus for use in subterranean wells, and in particular contemplate improved apparatus and methods for using a radially expandable sand-control screen jacket and sand or gravel packing in a subterranean well.

BACKGROUND OF THE INVENTIONS

The control of the movement of sand and gravel into a well bore has been the subject of much importance in the oil production industry. The introduction of sand or gravel into the well bore commonly occurs under certain well conditions. The introduction of these materials into the well commonly causes problems including, plugged formations or well tubings, and erosion of tubing and equipment. There have therefore been numerous attempts to prevent the introduction of sand and gravel into the production stream.

One method of sand-control is the use of sand-control screen jackets to exclude sand from the production stream. The use of a radially expandable sand-control screen jacket includes causing the radial expansion of a base pipe and surrounding screen jacket by drawing a mechanical expansion tool up through the base pipe from the bottom of the hole. United States Patent Number 5,901,789 to Donnelly for example, discloses expanding a slotted steel tube by pulling an expansion cone upwardly through the tube. Problems exist in the practice of the art. One problem is that during expansion, the expansion tool can become lodged in the hole. In the current state of the art, it is very difficult to reverse the direction of the expansion tool to attempt to dislodge it.

Sand or gravel packing around the outside of a sand-control screen is sometimes performed

in conjunction with sand-control screen installation. Sand or gravel packing is the controlled introduction of a selected sand or gravel into the annular space between a sand-control filter and the side of the wellbore. Generally, an attempt is made to entrap the selected packing medium in the annular space between the expanded screen and the edge of the hole. United States Patent Number 5 6,012,522 to Donnelly, discloses the injection of bonding agent-coated granules into an expanded slotted tube, wiping the excess from the interior of the tube, and allowing the bonding agent to cure. Problems exist with this state of the art. The '522 method, has the problems noted above, in that the expansion cone can become lodged in the unexpanded tube. Additionally, the expansion cone is subject to becoming inadvertently bonded in place. Another problem is that the application of 10 bonding agent-coated granules may leave gaps in coverage where sand can enter the production stream. Another problem with this method is the necessity of using a granule sized to fit through the tube slots. These problems may lead to the hole becoming filled with sand or in all of the sand washing out of the hole.

Due to the aforementioned problems with the introduction of sand and gravel into the 15 production stream, a need exists for apparatus and methods for inserting a radially expandable sand-control screen jacket assembly into a well, radially expanding the screen jacket assembly, and sand or gravel packing the annular space between the expanded screen and the wall of the well.

SUMMARY OF THE INVENTIONS

20 In general, the inventions provide apparatus and methods for injecting sand or gravel packing medium between a radially expandable sand-control screen jacket, and radially expanding the screen jacket with an expansion tool moving either downward or upward through the well. Packing medium granules are sized to be excluded by the screen mesh. In a method of the

invention for sand-control in a subterranean well, steps are taken to place a radially expandable sand-control screen jacket assembly into the well, place the expansion tool of the invention into the well, and move the expansion tool longitudinally through the well causing the screen jacket assembly to radially expand.

5 According to one aspect of the invention, a sand-control medium is pumped into the well around the outer surface of the screen jacket assembly.

 According to another aspect of the invention, the screen jacket assembly is expanded from the top down.

 According to another aspect of the invention, the screen jacket assembly is expanded from
10 the bottom up.

 According to yet another aspect of the invention, the expansion tool comprises a self-contained downhole force generator.

BRIEF DESCRIPTION OF THE DRAWINGS

15 The accompanying drawings are incorporated into and form a part of the specification to illustrate several examples of the present inventions. These drawings together with the description serve to explain the principals of the inventions. The drawings are only for the purpose of illustrating preferred and alternative examples of how the inventions can be made and used and are not to be construed as limiting the inventions to only the illustrated and described examples. The
20 various advantages and features of the present inventions will be apparent from a consideration of the drawings in which:

 FIGURE 1 is a longitudinal cross-sectional view of apparatus and steps in methods of using a radially expandable sand-control screen jacket;

FIGURE 2 is a longitudinal cross-sectional view of another example of apparatus and steps in of using a radially expandable sand-control screen jacket;

FIGURE 3 is a longitudinal cross-sectional view of another example of apparatus and methods of using a radially expandable sand-control screen jacket;

5

DETAILED DESCRIPTION

The present inventions are described by reference to drawings showing one or more examples of how the inventions can be made and used. In these drawings, reference characters are used throughout the several views to indicate like or corresponding parts.

10

In the description which follows, like or corresponding parts are marked throughout the specification and drawings with the same reference numerals, respectively. The drawings are not necessarily to scale and the proportions of certain parts have been exaggerated to better illustrate details and features of the invention. In the following description, the terms "upper," "upward," "lower," "below," "downhole", "longitudinally" and the like, as used herein, shall mean in relation to the bottom, or furthest extent of, the surrounding wellbore even though the wellbore or portions of it may be deviated or horizontal. Correspondingly, the "transverse" orientation shall mean the orientation perpendicular to the longitudinal orientation. The term "sand-control" used herein means the exclusion of particles larger in cross section than a chosen size, whether sand, gravel, mineral, soil, organic matter, or a combination thereof.

15

20

Apparatus and methods for constructing and deploying screen jackets are used in conjunction with the inventions, but are not critical thereto. Exemplary sand-control screens and methods of their deployment in a well are disclosed in United States Patent Numbers 5,931,232 and 5,850,875, both of which are assigned to the assignee of this application and are incorporated

herein for all purposes by this reference.

Referring in general to Figures 1-3, the general structure and methods of using the radially expandable sand-control screen jacket assembly 10 utilizing the present inventive concepts is shown. The radially expandable screen jacket assembly 10 is inserted into the production zone 12 of a wellbore 14. It should be understood that the screen jacket assembly 10 need not be located at the end 16 of the wellbore 14 as shown in Figures 1 and 2. As shown in Figure 3, the screen jacket assembly 10 may of course be connected to a casing 18 at either end. The connection 20 between the casing 18 and the screen jacket assembly 10 may be made in the conventional manner and is not critical to the inventions so long as a sand-controlling joint is provided. The wellbore 14 is substantially cylindrical but typically has irregularities such as gaps 22 randomly distributed throughout its length. The screen jacket assembly 10 has a base pipe 24 at its center. The base pipe 24 has a plurality of perforations 26 through which fluids in the well enter the interior of the base pipe 24. Throughout the Figures, the sand-control screen jacket assembly 10 is referred to generally with the numeral 10. When differentiating between the expanded and unexpanded states of the screen jacket assembly, the illustrations carry the additional designations 10a, referring specifically to the unexpanded screen jacket assembly, and 10b, referring specifically to the expanded screen jacket assembly. The sand-control screen jacket assembly 10 may be comprised of one or more concentric inner 28 and outer screens 30 with or without a layer of prepacked sand 32 between screens. The screen jacket assembly 10 may optionally have a screen shroud 34 concentrically surrounding the screens 28, 30. The exact configuration of the screen jacket assembly 10 is not critical to the invention and may be varied by those skilled in the arts. With the screen jacket assembly 10 inserted into the desired location of the wellbore 14 in the conventional manner, an annular space 36 exists between the outer surface 38 of the screen jacket assembly 10a and the wall

of the wellbore 14.

With further reference to Figure 1, a wash pipe 40 is inserted into the unexpanded screen jacket assembly 10a. The terminal end 42 of the wash pipe 40 is equipped with an outlet valve or nozzle, preferably a float shoe 44. The other end of the wash pipe 40 is connected to a pump (not shown). In practicing the invention a packing medium 46, such as sand granules of a selected size
5 suspended in slurry, is pumped into the annular space 36 between the unexpanded screen jacket assembly 10a and the wall of the wellbore 14. The annular space 36 is typically not filled or tightly packed with packing medium 46. Space is left to allow for expansion of the screen jacket 10. Of course, as further discussed below with reference to Figure 3, in cases where an additional pipe
10 string portion is located downhole from the screen jacket assembly 10, the wash pipe extends a location where the packing medium-slurry mixture is injected into a port in a conventional manner. It will also be apparent to those skilled in the arts that additional fluid such as a gel medium (not shown) may be pumped into the wellbore in order to help position the packing medium. The wash pipe 40 is preferably removed after a predetermined quantity of packing medium 46 has been
15 pumped into the annular space 36.

Referring now primarily to Figure 2, after the wash pipe (not shown) has been removed, the expansion tool 50 is positioned at the upper end of the sand-control screen jacket 10a. An expansion cone 52 portion of the expansion tool is preferably mechanically connected to a hydraulic downhole force generator 54. The downhole force generator 54 is preferably self-contained, or may
20 be in communication to the surface via slickline, power connections, or control connections. Optionally, the weight of the work string may be applied to the expansion tool to supply downward force. The exact configuration of the expansion tool is not critical to the invention so long as sufficient force is applied to facilitate longitudinal movement of the tool and radial expansion of the

screen jacket. The unexpanded screen jacket 10a is forced radially outward by the expansion cone 52, to produce expanded screen jacket 10b. In practicing the inventions, the expansion tool 50 may be moved further downhole and activated as many times as required to expand the screen jacket assembly 10 for the desired length of wellbore 18. After the screen jacket 10 expands, the packing medium 46 preferably substantially fills the annular space 36 between the screen jacket assembly 10 and the wellbore 14. It is not critical to the invention that the annular space 36 be filled, completely or substantially, when the screen jacket 10 is in its expanded state. Those skilled in the art will of course realize that the expansion aspect of the invention may be practiced without the introduction of packing medium 46 into the wellbore.

In an alternative embodiment of the inventions depicted in Figure 3, a casing 18 extends in either direction in the wellbore 14 with a production zone 12 located therebetween. The expansion tool 50 is placed downhole of the production zone 12. A sand-control screen jacket assembly 10 is then deployed spanning the production zone 12. A gel medium 68 and packing medium 46 may then in turn be introduced into the wellbore 14 by a pump and wash pipe (not shown) such that packing medium 46 is held in the production zone 12. The gel medium 68 and packing medium 46 are preferably injected into the wellbore 14 through a port 70 in the casing 18. However, the gel and packing medium may alternatively be injected and pumped to position from the bottom of the hole. The unexpanded screen jacket 10a is forced radially outward by the expansion cone 52, to produce expanded screen jacket 10b. The downhole force generator 54 may be self-contained as preferred, or may be in communication to the surface via slickline, power connections, or control connections. In practicing the inventions, the expansion tool 50 may be moved further upward and activated as many times as required to expand the screen jacket assembly 10 for the desired length of wellbore 14. As the screen jacket 10 expands, the packing medium 46 preferably, but not

Hal's —

necessarily, substantially fills the annular space 36 between the screen jacket assembly 10b and the wellbore 14. Those skilled in the arts will of course realize that the expansion aspect of the invention may be practiced without the introduction of packing medium 46 into the wellbore.

It will be clear to those skilled in the art that either embodiment described herein may be practiced with either screen jacket assembly deployment in a production zone described. It will also be clear that the apparatus and methods disclosed may be used for top-down or bottom-up screen expansion. The inventions have several advantages over the apparatus and methods previously known in the art, including the advantages of providing thorough gravel packing around the wellbore and the ability to expand a screen jacket assembly moving in either the downhole or upward direction. Additionally, the combination of an expandable screen jacket assembly with appropriately sized packing medium placed outside the screen jacket assembly provides better assurance of achieving a sand-controlling surface than methods which rely on pressing a small-particle sand-controlling medium through a relatively large-mesh screen jacket assembly. The self-contained expansion tool also provides advantages including the elimination of surface connections.

The embodiments shown and described above are only exemplary. Many details are often found in the art such as: screen or expansion cone configurations and materials. Therefore, many such details are neither shown nor described. It is not claimed that all of the details, parts, elements, or steps described and shown were invented herein. Even though numerous characteristics and advantages of the present inventions have been set forth in the foregoing description, together with details of the structure and function of the inventions, the disclosure is illustrative only, and changes may be made in the detail, especially in matters of shape, size and arrangement of the parts within the principles of the inventions to the full extent indicated by the broad general meaning of the terms used in the attached claims.

The restrictive description and drawings of the specific examples above do not point out what an infringement of this patent would be, but are to provide at least one explanation of how to make and use the inventions. The limits of the inventions and the bounds of the patent protection are measured by and defined in the following claims.

WHAT IS CLAIMED:

1 1. A method of sand-control in a subterranean well comprising the steps of:
2 inserting a radially expandable sand-control screen jacket assembly into the well and
3 thereafter pumping sand-control medium into the annular space between the outer surface of the
4 screen jacket assembly and the wellbore wall;
5 inserting an expansion tool into the well; and
6 moving the expansion tool through the screen jacket assembly causing the screen jacket
7 assembly to radially expand.

1 2. A method of sand-control in a subterranean well according to claim 1 wherein
2 the expansion tool is moved through the screen jacket assembly from top to bottom.

1 3. A method of sand control in a subterranean well according to claim 1 wherein
2 the expansion tool further comprises a self-contained downhole force generator.

1 4. A method of sand-control in a subterranean well according to claim 1 wherein
2 the packing medium substantially fills the annular space between the outer surface of the screen
3 jacket assembly and the wellbore wall after the step of moving the expansion tool through the
4 screen jacket assembly.

1 5. A method of sand-control in a subterranean well comprising the steps of:
2 inserting an expansion tool into the well; then
3 inserting a radially expandable screen jacket assembly into the well above the expansion
4 tool; then
5 pumping sand-control medium into the annular space between the outer surface of the
6 screen jacket assembly and the wellbore wall; and
7 moving the expansion tool through the screen jacket assembly causing the screen jacket
8 assembly to radially expand.

1 6. A method of sand control in a subterranean well according to claim 5 wherein the
2 expansion tool further comprises a self-contained downhole force generator.

1 7. A method of sand-control in a subterranean well according to claim 5 wherein the
2 packing medium substantially fills the annular space between the outer surface of the screen jacket
3 assembly and the wellbore wall, after the step of moving the expansion tool through the screen
4 jacket assembly.

1 8. A method of sand-control in a subterranean well according to claim 5 wherein the
2 expansion tool is moved through the screen jacket assembly from top to bottom.

1 9. Apparatus for radially expanding a sand-control screen jacket assembly in a subterranean
2 well comprising:

3 an expansion cone; and

4 a downhole force generator operably connected to the expansion cone for moving the
5 expansion cone through the sand-control screen jacket assembly and causing the screen jacket
6 assembly to radially expand.

1 10. Apparatus for radially expanding a sand-control screen shroud assembly in a
2 subterranean well according to claim 10 wherein the downhole force generator is self-contained.

1 11. Apparatus for radially expanding a sand-control screen shroud assembly in a
2 subterranean well according to claim 10 wherein the downhole force generator further comprises an
3 electric battery operably connected to an electric motor.

1 12. Apparatus for radially expanding a sand-control screen shroud assembly in a
2 subterranean well according to claim 1 wherein the downhole force generator further comprises an
3 activation assembly.

ABSTRACT

The inventions provide apparatus and methods for radially expanding a sand-control screen jacket in a subterranean well. The expansion can be achieved with the longitudinal movement of an expansion tool in either the downhole or upward direction. A method is also provided for placing
5 sand or gravel packing medium in a wellbore around a radially expandable sand-control screen prior to expansion.